MODIS Level 2 Land Surface Reflectance Science Processing Algorithm

MOD09_SPA

General

The NASA Goddard Space Flight Center's (GSFC) Direct Readout Laboratory (DRL), Code 606.3 developed this wrapper software for the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) In-Situ Ground System (NISGS) and the International Polar Orbiter Processing Package (IPOPP).

Users must agree to all terms and conditions in the Software Usage Agreement on the DRL Web Portal before downloading this software.

Software and documentation published on the DRL Web Portal may occasionally be updated or modified. The most current versions of DRL software are available at the DRL Web Portal:

http://www.directreadout.sci.gsfc.nasa.gov

Questions relating to the contents or status of this software and its documentation should be addressed to the DRL via the Contact Us mechanism at the DRL Web Portal:

http://directreadout.sci.gsfc.nasa.gov/index.cfm?section=contact%20usAlgorithm

Algorithm Wrapper Concept

The DRL has developed an algorithm wrapper to provide a common command and execution interface to encapsulate multi-discipline, multi-mission science processing algorithms. The wrapper also provides a structured, standardized technique for packaging new or updated algorithms with minimal effort.

A Science Processing Algorithm (SPA) is defined as a wrapper and its contained algorithm. SPAs will function in a standalone, cross-platform environment to serve the needs of the broad Direct Readout community. Detailed information about SPAs and other DRL technologies is available at:

http://directreadout.sci.gsfc.nasa.gov/index.cfm?section=technology

Software Description

This DRL software package contains the MODIS Land Surface Reflectance Science Processing Algorithm (MOD09_SPA). The MOD09_SPA creates the MODIS Level 2 Land Surface Reflectance product. The MOD09 algorithm used in this package is the same as the algorithm used for global MODIS Collection 5 processing at GSFC. The MOD09_SPA processes arbitrary sized granules, and simplifies the ancillary

data requirements. The MOD09_SPA will work with either the grib1 or grib2 ancillary files. Beginning in September 2008, the NCEP meteorology data will be available in grib2 format only.

Software Version

Version 1 of the DRL algorithm wrapper was used to package the SPA described in this document.

Credits

The Land Surface Reflectance algorithm (Version 5.3.18) was developed by the NASA MODIS Science Team. The MOD09_SPA packaging was developed by the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin (UW) and the DRL. The 'cnvgrib' utility was developed by the National Centers for Environmental Prediction (NCEP), an arm of the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS). The source files to build the utility can be accessed at: http://www.nco.ncep.noaa.gov/pmb/codes/GRIB2/.

Prerequisites

To run this package, you must have the Java Development Kit (JDK) or Java Runtime Engine (JRE) (Java 1.5 or higher) installed on your computer, and have the Java installation bin/ subdirectory in your PATH environment variable.

Program Inputs and Outputs

This SPA requires MODIS 1km, half km and quarter km L1B Calibrated Geolocated Radiances HDF and MODIS Geolocation HDF input products, and utcpole, leapsec, and meteorology ancillary files.

The SPA also requires input data platform, scan date and scan time information. These data and the MODIS L1B input products can be obtained from the DRL ftpsite for the eastern U.S. region:

For Terra MODIS: ftp://is.sci.gsfc.nasa.gov/gsfcdata/terra/modis/level1/
For Aqua MODIS: ftp://is.sci.gsfc.nasa.gov/gsfcdata/aqua/modis/level1/

Datasets from other areas can be obtained either from the Distributed Active Archive Center (DAAC) or from other Direct Readout stations.

Output is the MODIS Level 2 Land Surface Reflectance product.

Installation and Configuration

This section contains instructions for installing an SPA in a standalone configuration. SPAs may also be installed dynamically into an IPOPP framework; instructions for this type of installation are contained in the IPOPP User's Guide.

Download the MOD09_5.3.18_SPA.tar.gz and MOD09_5.3.18_SPA_testdata.tar.gz (optional) files into the same directory.

Decompress and un-archive the MOD09_5.3.18_SPA.tar.gz and MOD09_5.3.18_SPA_testdata.tar.gz (optional) files:

```
$ tar -xzf MOD09_5.3.18_SPA.tar.gz
$ tar -xzf MOD09_5.3.18_SPA_testdata.tar.gz
```

This will create the following subdirectories:

- SPA
  - mod09
    - algorithm
    - station
    - wrapper
    - testscripts
    - testdata

For convenience, this package contains statically linked binaries for Red Hat Enterprise 4.5 (32-bit). These binaries should run on most recent 32-bit and 64-bit distributions. Source code is also included. If you get an error message while running the testscripts (refer to next section "Software Package Testing and Validation"), you may need to recompile the software for your platform/OS combination. Refer to the Appendix for instructions on recompiling the software.

The MOD09_SPA uses a script that checks for the number of night scans in a granule and does not process granules that have night scans in them. By default the maximum number of night scans allowed is set to 0. This default may be changed by modifying the value of the MAX_NO_NIGHT_SCANS variable inside the following script:

$yourpathto/SPA/mod09/algorithm/DRLshellscripts/DayNight.csh

Software Package Testing and Validation

The testscripts subdirectory contains a test script that can be used to verify that your current installation of the SPA is working properly, as described below. Note that the included MOD09_5.3.18_SPA_testdata.tar.gz file is required to execute these testing procedures.

Step 1: cd into the testscripts directory.

Step 2: Run the run-mod09 script by typing: $./run-mod09

A successful execution usually takes some time (around 10 minutes or more, depending on the speed of your computer and size of the input files), so if the execution seems to get stuck, do not become impatient. If everything is working properly, the scripts will terminate with a message such as:

Output modis.mod09.l2 is
/home/ipopp/drl/SPA/mod09/testdata/output/MYD09.08077195240.hdf

You can cd to the output directory to verify that the science product really exists. If it does exist, then the wrapped SPA works perfectly. If there is a problem and the code terminates abnormally, the problem can be identified using the log files. Log files are automatically generated within the directory used for execution. They start with stdfile* and errfile*. Other problems may be caused by incompatibility between your system and the binaries provided with this software package. In that case you may need to recompile the software for your platform/OS combination. Refer to the Appendix for instructions on recompiling. Please report any errors that cannot be fixed to the DRL. Use the script 'run-mod09-autodownload' if you want the algorithm to fetch its own ancillary, and the script 'run-mod09-grib2input' if you want to run the SPA using grib2 files as input.

Test output product(s) are available for comparison in the testdata/output directory.

Program Operation

In order to run the package using your own input data, you can either use the 'run' scripts within the wrapper subdirectories, or modify the test scripts within the testscripts subdirectory.

To Use the Run Scripts

Identify the 'run' scripts: The wrapper/mod09 directory contains the 'run' script. Execute the 'run' as described below to execute the MOD09_SPA. Note that to execute 'run', you must have java on your path.

Specify input parameters using <label value> pairs: To execute the 'run' scripts, you must supply the required input and output parameters. Input and output parameters are usually file paths. Each parameter is specified on the command line by a <label value> pair. Labels are simply predefined names for parameters. Each

label must be followed by its actual value. Each SPA has its own set of <label value> pairs that must be specified in order for it to execute. Some of these pairs are optional, meaning the process would still be able to execute even if that parameter was not supplied. The MOD09_SPA uses three kinds of label/value pairs, as follows:

a) Input file label/values. These are input file paths. Values are absolute or relative paths to the corresponding input file.

b) Parameter label/values. These are parameters that need to be passed onto the SPA (e.g., leapsec, utcpole and meteorology files).

c) Output files labels. These are output files that are produced by the SPA.

The following tables contains a list of labels, and their descriptions, that are needed by the SPA.

Input File Labels	Description	Data Sources
modis.mxd021km	MODIS 1km L1B Calibrated Geolocated Radiances HDF file (MOD021KM, MYD021KM).	DRL ftp site for real time datasets over eastern US region: Terra: ftp://is.sci.gsfc.nasa.gov/gsfcdata/terra/modis/level1/ Aqua: ftp://is.sci.gsfc.nasa.gov/gsfcdata/aqua/modis/level1/ Datasets from your Direct Readout Station.
modis.mxd02hkm	MODIS 500m L1B Calibrated Geolocated Radiances HDF file (MOD02HKM, MYD02HKM).	
modis.mxd02qkm	MODIS 250m L1B Calibrated Geolocated Radiances HDF file (MOD02QKM, MYD02QKM).	
modis.mxd03	MODIS Geolocation HDF file (MOD03, MYD03).	
utcpole (optional)	Earth motion file.	Recent ancillary data can be found at: ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/
leapsec (optional)	Leap seconds file.	
ncep.met.pre (optional)	Directory path and filename of forecasted or observed meteorological data from National Centers for Environmental Prediction (NCEP) meteorological ancillary data product available for the nearest time preceding the time of L1B product's first scan line.	Recent ancillary data can be found at: ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/global/gdas/ Archived ancillary data can be found at: ftp://ftp.ssec.wisc.edu/pub/eosdb/ancillary/
ncep.met.post (optional)	Directory path and filename of forecasted or observed meteorological data from NCEP meteorological ancillary data product available for the nearest time following the time of L1B product's last scan line.	

Parameter Labels	Description
platform	'aqua' or 'terra'.
scandate	Date when the granule was acquired in hhmm format.
scantime	The start time of the L1B swath in yyyyddd format. Note that ddd refers to the day of the year. If your input L1B files follow the standard DAAC L1B file naming convention (e.g., MYD021KM.Ayyyydddhhmmss.xxxxxxx.hdf), this information can be found in the filename itself.
gribtype	1 if grib1, or 2 if grib2.
updateul (optional)	'yes' or 'no' (default). If set to 'yes', the most recent utcpole and leapsec file will be downloaded.
Output file Labels	**Description**
modis.mod09.l2	Land Surface Reflectance product.

NOTES:

1. If any of the optional parameters like utcpole, leapsec, ncep.met.pre and ncep.met.post are not specified or point to a null file, the SPA will allow the algorithm to fetch its own ancillary files (auto-download mode). In auto-download mode, the algorithm first determines the date and time of the NCEP Global Data Assimilation System (GDAS) analysis ancillary data files, which bracket the MODIS observation time. The GDAS files are available at 00, 06, 12, and 18 UTC daily. If the GDAS file for a given MODIS observation time is not yet available (i.e., you are processing real-time data), NCEP Global Forecast System (GFS) forecast files are used instead. The script will check your local disk to determine whether the ancillary data files are already present. If they are not present, the script will attempt to download the required GDAS or GFS files from the Space Science and Engineering Center (SSEC) at UW. Local ancillary data files are stored in $yourpathto/SPA/mod09/algorithm/ancillary. You may want to delete the contents of this folder if it becomes too large. Remember to always set the parameter label gribtype to 1, and updateul to yes in auto-download mode..

2. If you are not using the auto-download feature but instead specifying your own ancillary files on the command line, find the corresponding NCEP GDAS analysis ancillary data files, which bracket the MODIS observation time. If the GDAS files are not available (i.e., you are processing real-time data) use the NCEP GFS files. If you choose GFS data as input, you should attempt to use a forecast time step that is closest to the analysis time. For example, if your data time is 15 UTC, you should try to use the 3 hour forecast field from the 12 UTC model run, instead of the 9 hour forecast field from the 06 UTC run.

Also, get the utcpole and leapsec data files and specify them in the command line. Follow the example script 'run-mod09' provided in the mod09/testscripts subdirectory in order to specify the ancillary data properly.

3. The MOD09_SPA includes the 'cnvgrib' utility for users who have grib2 data as input for their meteorological files. The MOD09_SPA testscripts directory contains a sample script, 'run-mod09-grib2input', which takes grib2 data as input and converts them to grib1 data as needed by the algorithm. Remember to set the proper gribtype parameter label whenever you run the SPA.

4. The file formats, naming conventions and sources of the various ancillary files necessary to run the SPA are described below.

   yyyy = 4 digit year (e.g., 2008).
   yy = 2 digit year (e.g., 08 for year 2008).
   mm = 2 digit month (e.g., 06 for June).
   dd = 2 digit day of the month.
   ddd = 3 digit day of the year (e.g., 001 for January 1st).
   hh = hour analysis (run) time.
   xx = forecast time step.

   Recent GDAS data in grib1and grib2 format can be acquired from the DRL ftp site at: ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/global/gdas/ The naming conventions for the files are gdas1.PGrbFhh.yymmdd.xxz for grib1 data, and gdas1.PGrbFhh.yymmdd.xxz.grib2 for grib2 data.

   Archived GDAS data in grib1 format can be acquired from the SSEC UW ftp site: ftp://ftp.ssec.wisc.edu/pub/eosdb/ancillary/yyyy_mm_dd_ddd/ The naming convention for the files is gdas1.PGrbFhh.yymmdd.xxz.

   Recent GFS data in grib1 and grib2 format can be acquired from the DRL ftp site at: ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/global/gfs/ The naming conventions for the files are gfs.thh.yymmdd.pgrbfxx for grib1 data, and gfs.thh.yymmdd.pgrbfxx.grib2 for grib2 data.

   Recent GFS data in grib1 format can be acquired from the SSEC UW ftp site: ftp://ftp.ssec.wisc.edu/pub/eosdb/ancillary/yyyy_mm_dd_ddd/forecast The naming convention for the file is gfs.thh.yymmdd.pgrbfxx.

   utcpole and leapsec data can be downloaded from the DRL ftp site: ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/. Please choose the most recent files available.

5. The MOD09_SPA uses a script that checks for the number of night scans in a granule and does not process granules that have night scans in them. By default the maximum number of night scans allowed is set to 0. This default may be changed by modifying the value of the MAX_NO_NIGHT_SCANS variable inside the following script:

   $yourpathto/SPA/mod09/algorithm/DRLshellscripts/DayNight.csh

Execute the 'runs': The following is an example of a command line to run the MOD09_SPA from the mod09/testscripts subdirectory. You can run it from any directory of your choice, by using the correct paths to the 'run' script and your datasets.

```
$ ../wrapper/mod09/run \
    modis.mxd02qkm   ../testdata/input/MYD02QKM.08077195240.hdf \
    modis.mxd02hkm ../testdata/input/MYD02HKM.08077195240.hdf \
    modis.mxd021km ../testdata/input/MYD021KM.08077195240.hdf \
    modis.mxd03  ../testdata/input/MYD03.08077195240.hdf \
    modis.mod09.l2 ../testdata/output/MYD09.08077195240.hdf \
    ncep.met.pre  ../testdata/input/gdas1.PGrbF00.080317.18z \
    ncep.met.post  ../testdata/input/gdas1.PGrbF00.080318.00z \
    utcpole  ../testdata/input/utcpole.dat \
    leapsec ../testdata/input/leapsec.dat \
    platform aqua \
    scandate 2008077 \
    scantime  1952 \
    gribtype 1
```

Output modis.mod09.l2 is
/home/ipopp/drl/SPA/mod09/testdata/output/MYD09.08077195240.hdf

A successful execution of 'run' usually takes some time (around 10 minutes or more, depending on the speed of your computer and size of the input files), so if the execution seems to get stuck, do not become impatient. If execution fails, you will see an error message indicating the cause of failure (e.g., a file cannot be found, or a label cannot be recognized). Correct it and run again. If the problem has some other cause, it can be identified using the log files. Log files are automatically generated within the directory used for execution. They start with stdfile* and errfile*. Log files are automatically generated within the directory used for execution. Other problems may be caused by incompatibility between your system and the binaries provided with this software package. In that case you may need to recompile the software for your platform/OS combination. Refer to the Appendix for instructions on recompiling. The executions will create some temporary files (or symbolic links) in your execution directory. Delete them after the run.

To Use the Script in the testscripts Directory

One simple way to run the algorithms from any directory of your choice using your own data is to copy the 'run-mod09' script from the testscripts directory to the selected directory. Change the values of the variables WRAPPERHOME, L1HOME, and OUTPUTHOME to reflect the file paths of the wrapper directories and the input/output file paths, and then modify the input/output file name variables. Run the script to process your data.

Appendix
Instructions for Compiling the Software

In most cases, building the code should not be required, because statically linked binaries built with Red Hat Enterprise 4.5 (32-bit) are supplied. However, if you wish to build the code, the following compilers are required: GNU C Compiler gcc version 4.2.1, including the GNU Fortran Compiler gfortran. A script is supplied to automate the build process.

First, set the environment variable MODIS_DB_HOME to the full path of the directory where you unpacked the tarfile, and then execute the setup script.

For bash users:
$ export MODIS_DB_HOME=$yourpathto/SPA/mod09/algorithm

For C shell users:
% setenv MODIS_DB_HOME $yourpathto/SPA/mod09/algorithm

To run the build script, invoke:
$ ./modis_db_build.bash

This will build new statically linked versions of MOD_PR09DB.exe, MOD_PRDS1KM.exe, and MOD_PRDS500M.exe. However, note that the new versions will not overwrite the old versions of these files until they are copied to their respective bin directories. The script will show you how to do this when the compile is done.

NOTE: The DRL cannot guarantee that this code will build on all Linux distributions. The code uses a set of external libraries that are difficult to build from source, and are not included in source form in this package. If you need help building the code, please contact us via the DRL Web Portal:

http://directreadout.sci.gsfc.nasa.gov/index.cfm?section=contact%20us